

MCP1663
9V/12V/24V Output Boost Regulator Evaluation Board User's Guide

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Date

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MCP1663 9V/12V/24V OUTPUT BOOST REGULATOR EVALUATION BOARD USER'S GUIDE

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Preface

NOTICE TO CUSTOMERS

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Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXA", where "XXXXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board and a description of the user's guide.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

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RECOMMENDED READING

This user's guide describes how to use MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

- **MCP1663 Data Sheet - “High-Voltage Integrated Switch PWM Boost Regulator with UVLO” (DS20005406)**

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- Technical Support

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DOCUMENT REVISION HISTORY

Revision A (May 2015)

- Initial Release of this Document.

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Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board and covers the following topics:

- MCP1663 Short Overview
- What is the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board?
- What the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board Contains

1.2 MCP1663 DEVICE OVERVIEW

The MCP1663 is a compact, high-efficiency, fixed-frequency, non-synchronous step-up DC/DC converter which integrates a 36V, 400 mΩ switch. This product provides a space-efficient high voltage step-up, easy-to-use power supply solution. The MCP1663 was developed for applications powered by two-cell or three-cell alkaline, Energizer® Lithium Primary, Ni-Cd, Ni-MH batteries, or Li-Ion or Li-Polymer batteries.

The MCP1663 operates in Pulse-Width Modulation (PWM), at a fixed 500 kHz switching frequency. The device features an under-voltage lockout (UVLO) which prevents fault operation below 1.85V ($UVLO_{STOP}$) corresponding to the value of two discharged batteries. The MCP1663 starts its normal operation at 2.3V input voltage ($UVLO_{START}$) and the operating input voltage ranges from 2.4V to 5.5V.

For standby applications, MCP1663 can be put in Shutdown by pulling the EN pin to GND. The device will stop switching and will consume a few µA of input current (including feedback divider current; the device consumes 300 nA typical). In the Boost configuration, the input voltage will be bypassed to output through the inductor and Schottky diode.

MCP1663 also provides over-voltage protection (OVP) in the event of:

- Short-circuit of the feedback pin to GND
- Disconnected feedback divider

In these conditions, the OVP function will stop the internal driver and prevent damage to the device. This feature is disabled during the start-up sequence and Thermal Shutdown state.

The goal of the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board is to demonstrate the higher output voltage and output current capabilities of the MCP1663 Boost Converter.

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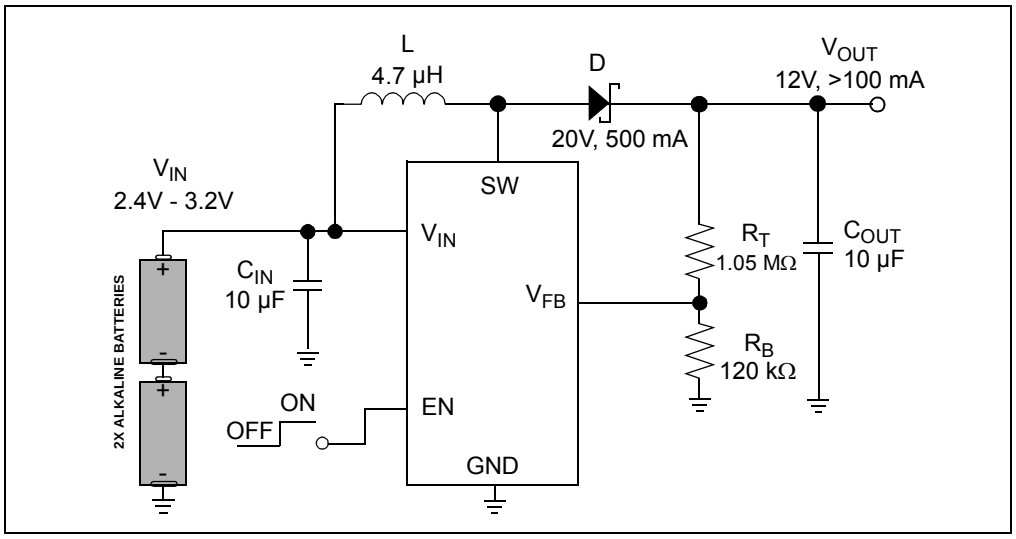


FIGURE 1-1: *Typical MCP1663 Boost Converter Two Alkaline Cells Input.*

1.2.1 HIGH INPUT VOLTAGE CONFIGURATION

The MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board comes with two additional configurations that can be used to extend and overcome the typical low V_{IN} voltage range, providing significantly more flexibility for applications powered from a higher input. The MCP1663 high-input voltage boost converter (the bottom circuit on the evaluation board) comes with two different solutions that can be used to extend the application's input voltage range beyond its typical values. For this circuit, V_{IN} represents the voltage applied between the VIN and GND test points on the board and V_{DD} represents the voltage that will be present on the MCP1663 input pin.

- The first option used for driving the MCP1663's low input (V_{DD}) voltage internal circuitry is to use a linear dropout regulator (LDO) to step-down the application supply voltage (V_{IN}) to 5V.
- The second solution to limit the V_{IN} voltage is to use a Zener diode regulator.

The MCP1663 low input quiescent current keeps the LDO and the Zener diode circuitry power losses at a low level.

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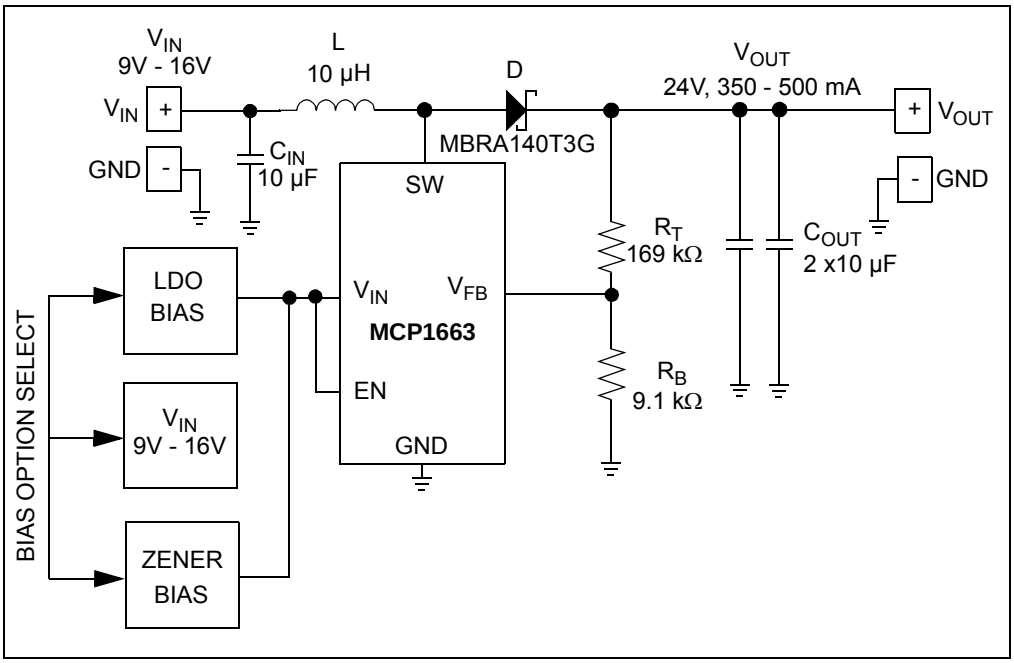


FIGURE 1-2: *MCP1663 24V Output Boost from HV Input (9V-16V).*

1.3 WHAT IS THE MCP1663 9V/12V/24V OUTPUT BOOST REGULATOR EVALUATION BOARD?

The MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board is used to evaluate and demonstrate Microchip Technology's MCP1663 Switching Boost Regulator. This board demonstrates the MCP1663 capabilities in two different applications:

- 9V or 12V selectable output Boost Converter application supplied from an external voltage source (V_{IN} < 5.5V e.g. Li-Ion cell boost to 9V or 12V). This typical step-up configuration is meant to highlight the MCP1663 basic boost operation.
- 24V Output Boost converter application supplied from high voltage input rail (e.g. 9V - 16V). This application provides solutions for the particular situation in which the required input voltage is outside the typical operating range (e.g. V_{IN} = 12V boost to 24V Output). J1 jumper is used to choose between stepping down the V_{IN} voltage using the LDO or the Zener diode circuitry.

The board can be used to evaluate the SOT-23-5 lead package. The MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board was developed to help engineers reduce product design cycle time.

The output voltage is set to the proper value using an external resistor divider, resulting in a simple and compact solution.

1.4 WHAT THE MCP1663 9V/12V/24V OUTPUT BOOST REGULATOR EVALUATION BOARD KIT CONTAINS

This MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board kit includes:

- MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board (ADM00664)
- Information Sheet

NOTES:

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Chapter 2. Installation and Operation

2.1 INTRODUCTION

MCP1663 is a non-synchronous, fixed-frequency step-up DC/DC converter which has been developed for applications that require higher output voltage capabilities. MCP1663 can regulate the output voltage up to 32V and can deliver up to 250 mA load at 3.3V input and 12V output (see Figure 2-3). At light loads, MCP1663 skips pulses to keep the output ripple low. The regulated output voltage (V_{OUT}) should be greater than the input voltage (V_{IN}).

Another important feature is that the device integrates the compensation and protection circuitry, such that the final solution lowers total system cost, eases implementation and requires a minimum number of additional components and board area.

2.1.1 MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board Features

The MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board has the following features:

- MCP1663 device can be evaluated in two separate applications:
  Typical 9V/12V Output supplied from low-input voltage source
  - Input Voltage range (V_{IN}): 2.4V to 5.5V, with $V_{IN} \leq V_{OUT}$
  - Output Current: typical 250 mA @ 12V Output, 3.3V Input
  - Enable state selectable using EN switch

  24V Output supplied from high input voltage source
  - Input Voltage range (V_{IN}): 9V to 16V
- Undervoltage Lockout (UVLO)
  - UVLO Start: 2.3V
  - UVLO Stop: 1.85V
- PWM Operation
- PWM Switching Frequency: 500 kHz
- Peak Input Current Limit of 1.8A (typical)
- Internal Compensation
- Soft Start
- Protection in case of feedback pin shorted to GND
- Overtemperature Protection (if the die temperature exceeds +150°C, with 15°C hysteresis)

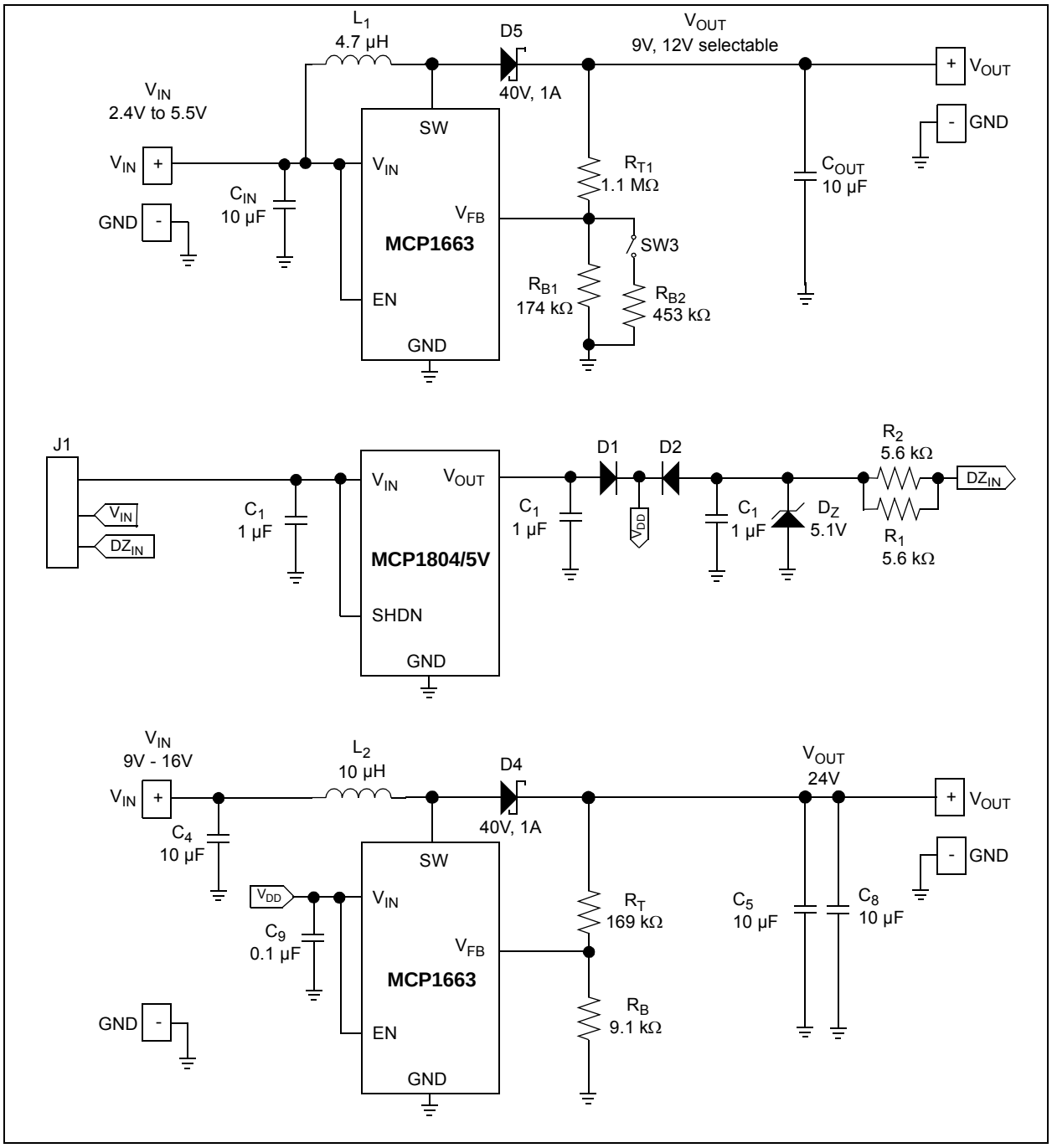


FIGURE 2-1: *MCP1663 Evaluation Board Schematic.*

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2.2 GETTING STARTED

The MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board is fully assembled and tested to evaluate and demonstrate the MCP1663 product. This board requires the use of external laboratory supplies and load.

2.2.1 Power Input and Output Connection

2.2.1.1 POWERING THE MCP1663 9V/12V/24V OUTPUT BOOST REGULATOR EVALUATION BOARD

The MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board was designed to be used to evaluate the MCP1663 device. The package selected is SOT-23.

Soldered test points are available for input voltage connections.

Soldered test points are available to connect a load. The switch peak current limit will provide a safe maximum current value. The maximum output current for the converter will vary with input and output voltages; refer to Figure 2-3 or the MCP1663 data sheet for more information on the maximum output current.

2.2.1.2 BOARD POWER-UP PROCEDURE

TOP CIRCUIT

1. Connect the input supply as shown in Figure 2-2. The input voltage should not be higher than 5.5V.
2. Connect system load to V_{OUT} and GND terminals; maximum load varies with input and output voltage. Connect the (+) side of the load to V_{OUT} and the negative (-) load to ground (GND).
3. The “VOUT SELECT” switch can be used to modify the output voltage between two values:
   - 9V, when the switch is in OFF position
   - 12V, when the switch is in ON position

BOTTOM CIRCUIT

1. Connect the input supply as shown in Figure 2-2.
2. The MCP1663 can be used in the extended input voltage range 9V - 16V.
3. Connect system load to V_{OUT} and GND terminals; maximum load varies with input and output voltage. Typically, the MCP1663 can supply a 24V output with 500 mA from a 12V input source at room temperature. Connect the (+) side of the load to V_{OUT} and the negative (-) load to ground (GND).
4. There are two distinct methods that can be used to extend the input voltage range:
   - Using an LDO to provide the necessary low voltage (V_{DD}) bias (jumper on J1 in “LDO” position)
   - Using a Zener diode (jumper on J1 in “Zener” position)

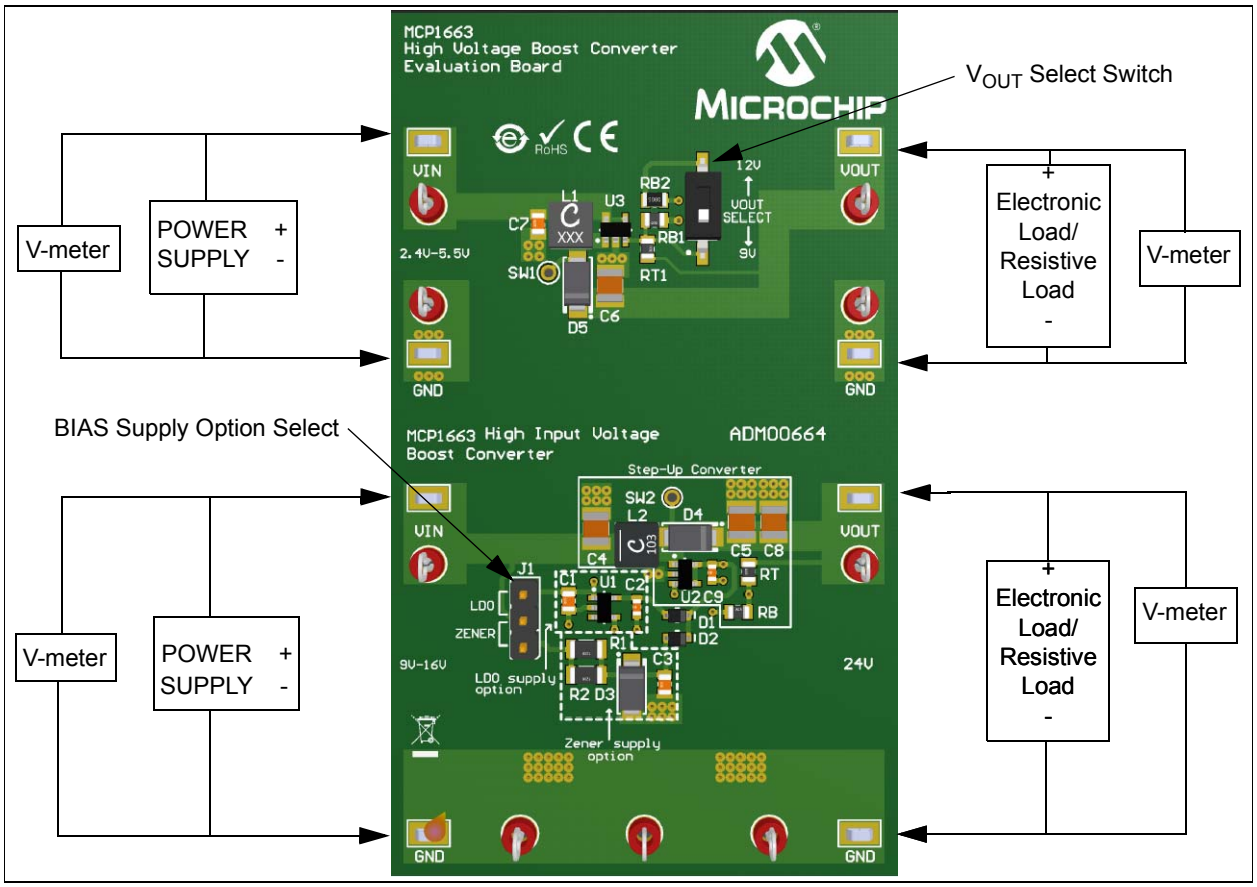


FIGURE 2-2: *MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board Setup.*

2.2.1.3 ADJUSTABLE V_{OUT} SETTING

The top circuit comes with the output value set to 9V and 12V (V_{OUT} selective using a switch). If a different output is desired, set the switch in the OFF state (button down) and recalculate the resistor divider (RT1 and RB1) using Equation 2-1.

The Bottom circuit comes with V_{OUT} set to 24V. As in the previous case, the same equation can be used to calculate RT and RB and set another output voltage. Note that V_{IN} must be lower than V_{OUT}.

EQUATION 2-1:

$$RT = RB \times \left[\left(\frac{V_{OUT}}{V_{FB}}\right) - 1\right]$$

Where: V_{FB} = 1.227V

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For output voltages higher than 15V, the inductor value should be increased. See Table 2-1 for more information.

TABLE 2-1: RECOMMENDED RESISTOR DIVIDER AND INDUCTOR VALUES

V_{OUT}	Inductor Value	RT	RB
6.0V	4.7 µH	1050 kΩ	270 kΩ
9.0V	4.7 µH	1000 kΩ	160 kΩ
12V	4.7 µH	1050 kΩ	120 kΩ
24V	10 µH	1050 kΩ	56 kΩ
32V	10 µH	1100 kΩ	43 kΩ

2.3 TEST RESULTS FOR TYPICAL APPLICATION USING MCP1663

2.3.1 Test Results for MCP1663 - TOP Circuit

This chapter provides specific operation waveforms and graphs. Refer to the MCP1663 Data Sheet (DS20005406) for more information.

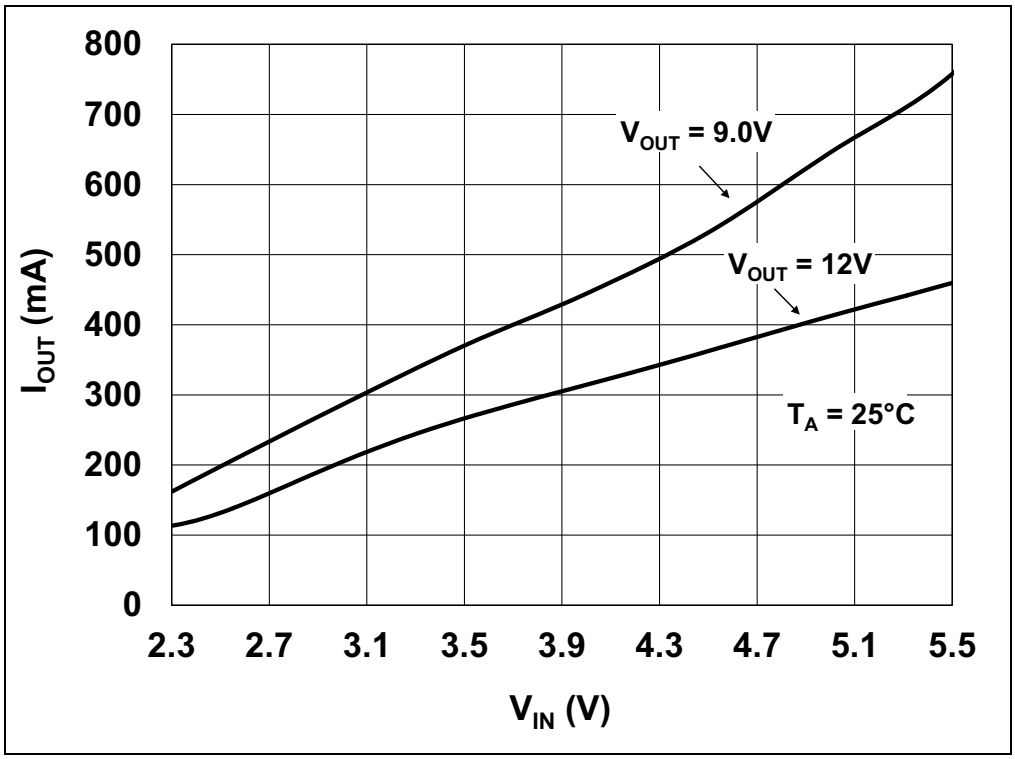


FIGURE 2-3: *MCP1663 Boost - 9V and 12.0 V_{OUT} Maximum I_{OUT} vs. V_{IN} with Maximum 5% Output Drop.*

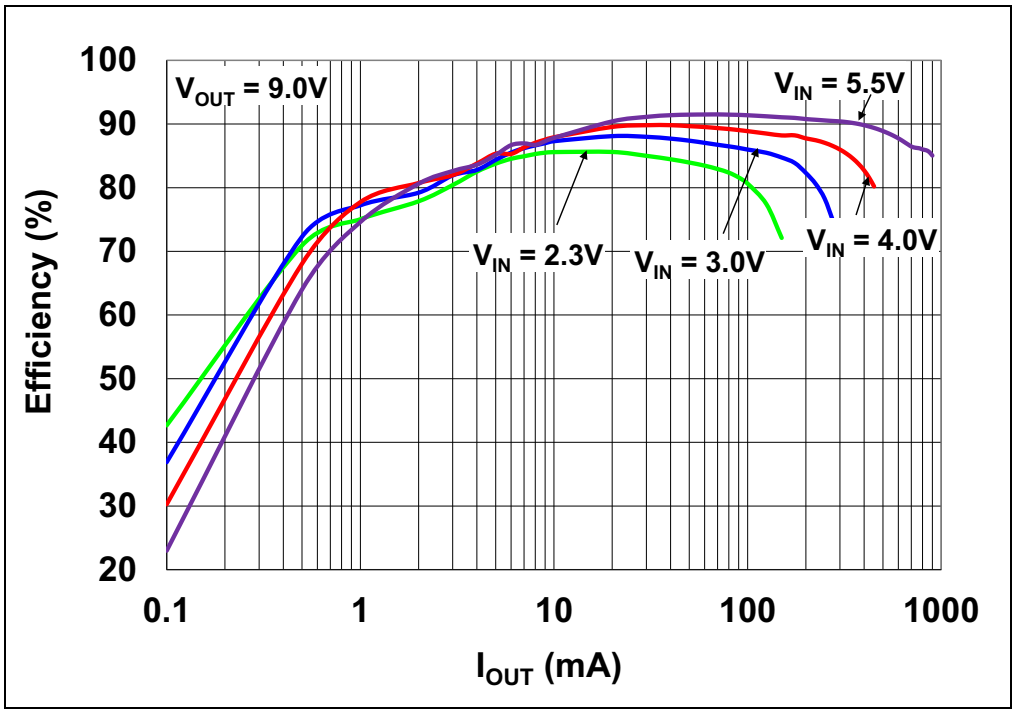


FIGURE 2-4: *MCP1663 9V Output Efficiency vs. I_{OUT}.*

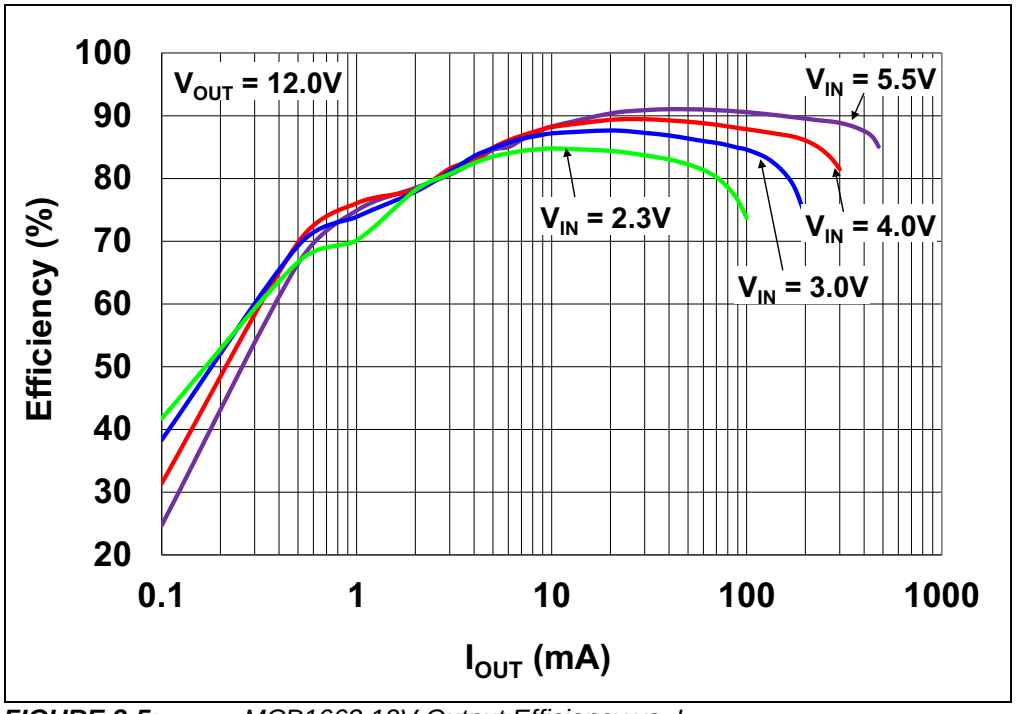


FIGURE 2-5: *MCP1663 12V Output Efficiency vs. I_{OUT}.*

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2.3.2 Test Results for MCP1663 - BOTTOM Circuit

The second circuit was developed for applications where an input voltage higher than the typical working range is needed. Refer to Figure 2-7 for the maximum output current that can be obtained for different input voltages.

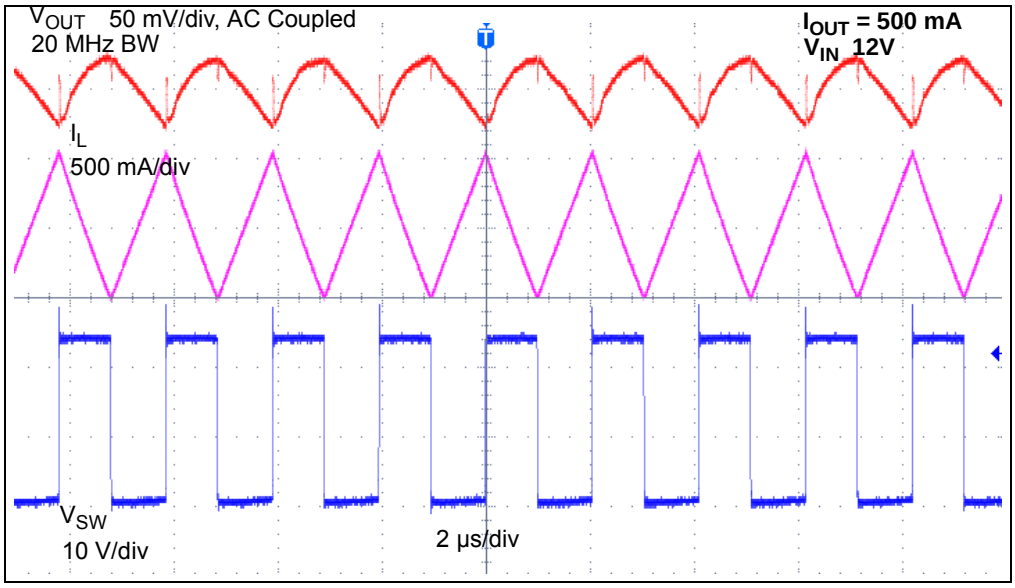


FIGURE 2-6: *MCP1663 24.0V V_{OUT} High Load Operation Waveforms.*

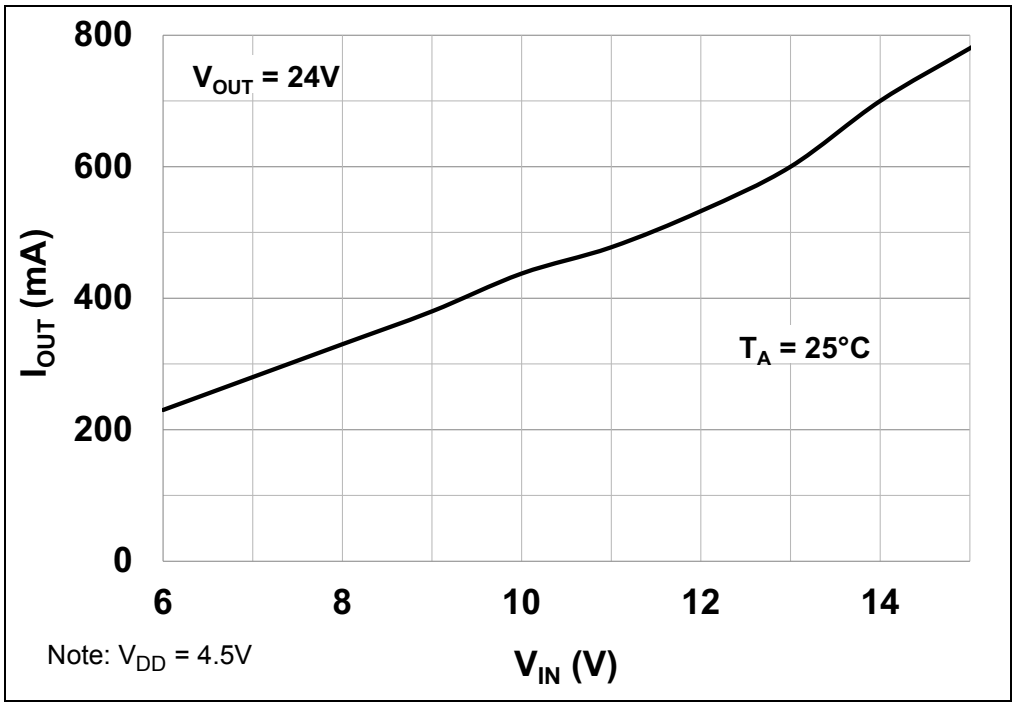


FIGURE 2-7: *MCP1663 Maximum I_{OUT} vs. V_{IN}.*

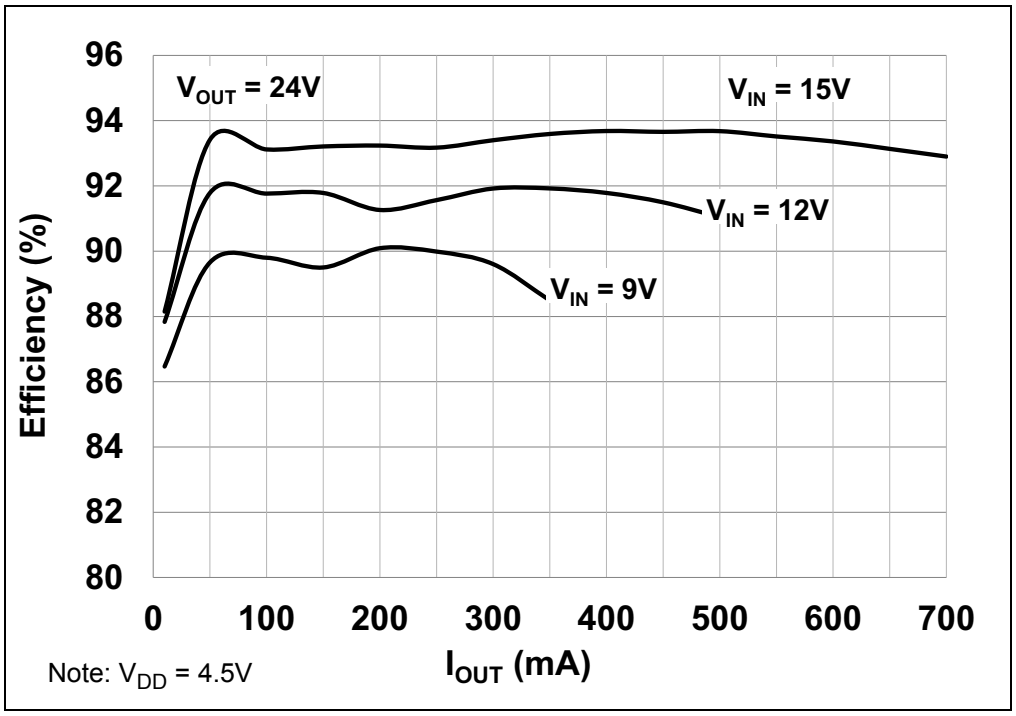


FIGURE 2-8: *MCP1663 Efficiency vs. I_{OUT}.*

2.4 BATTERY CONSIDERATIONS

When considering a power solution for a design, the battery needs to be carefully selected. Alkaline batteries are a commonly available option that delivers good performance in a variety of applications. Energizer® Ultimate Lithium batteries are an alternative power solution that provide superior-performance high drains and allows designers to utilize the full power range of the MCP1663 without sacrificing size or runtime.

Energizer Ultimate Lithium batteries utilize a primary cell chemistry that contain higher energy than alkaline batteries, and have much better high drain performance. Ultimate Lithium batteries produce a high, flat voltage profile that enables them to provide a high energy capacity even at high drains. Additionally, Ultimate Lithium batteries have a very low internal resistance, allowing them to maintain a high voltage at very high loads.

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Appendix A. Schematic and Layouts

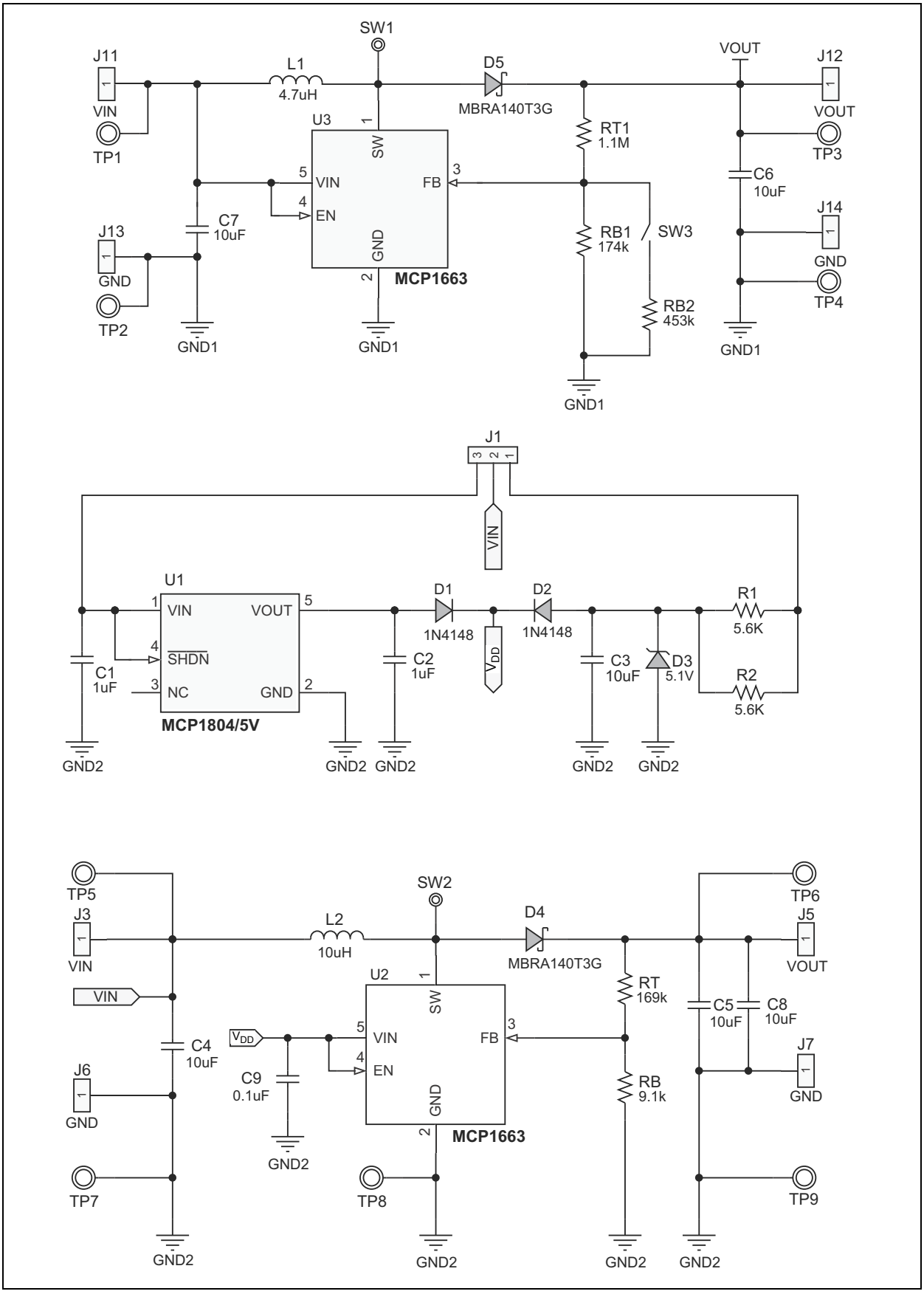
A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP1663 9V/12V/24V Output Boost Regulator Evaluation Board:

- Board – Schematic
- Board – Top Silk And Pads
- Board – Top Silk And Copper
- Board – Top Copper
- Board – Bottom Copper

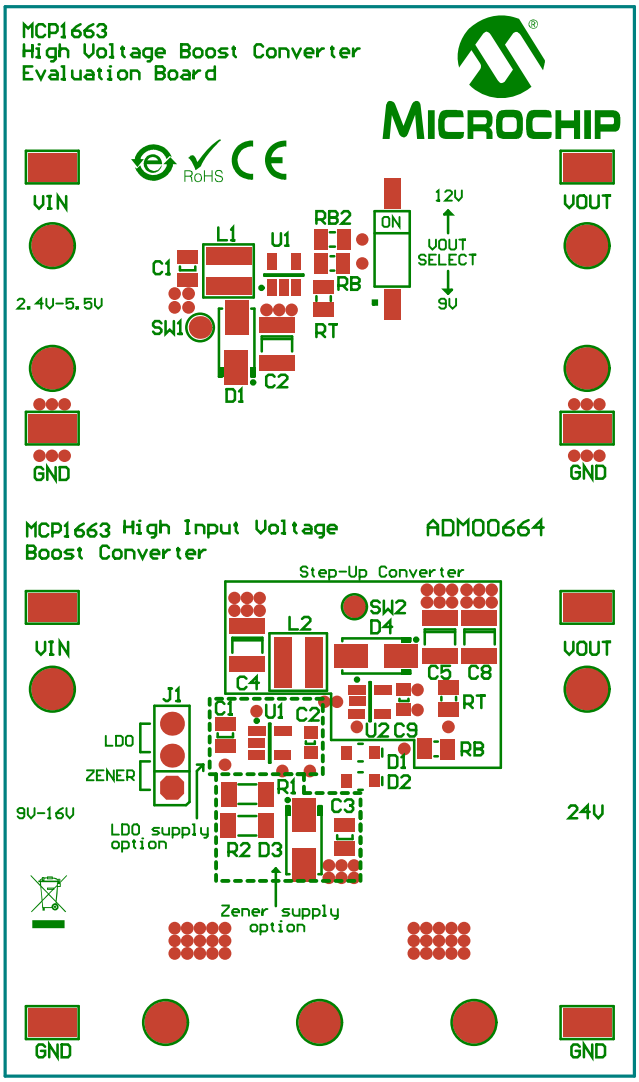
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A.2 BOARD – SCHEMATIC

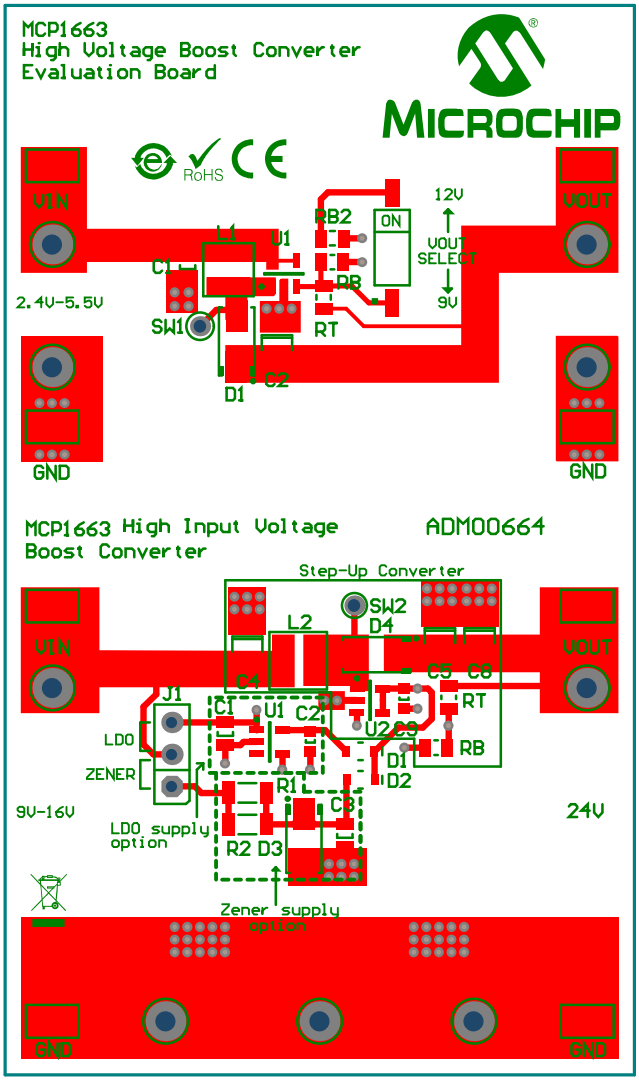


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A.3 BOARD – TOP SILK AND PADS

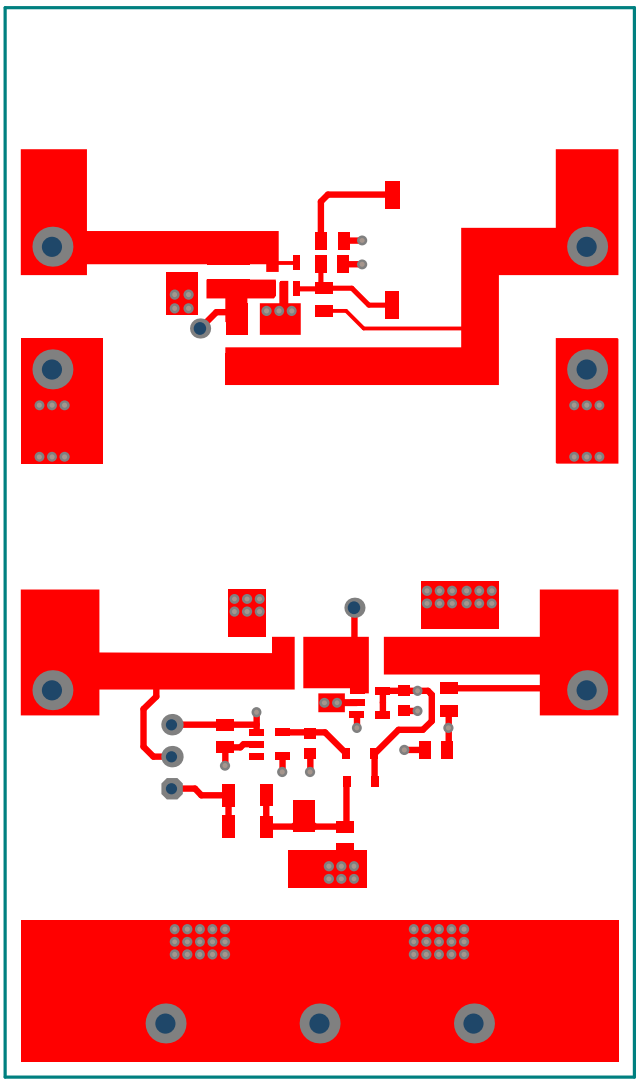


A.4 BOARD – TOP SILK AND COPPER

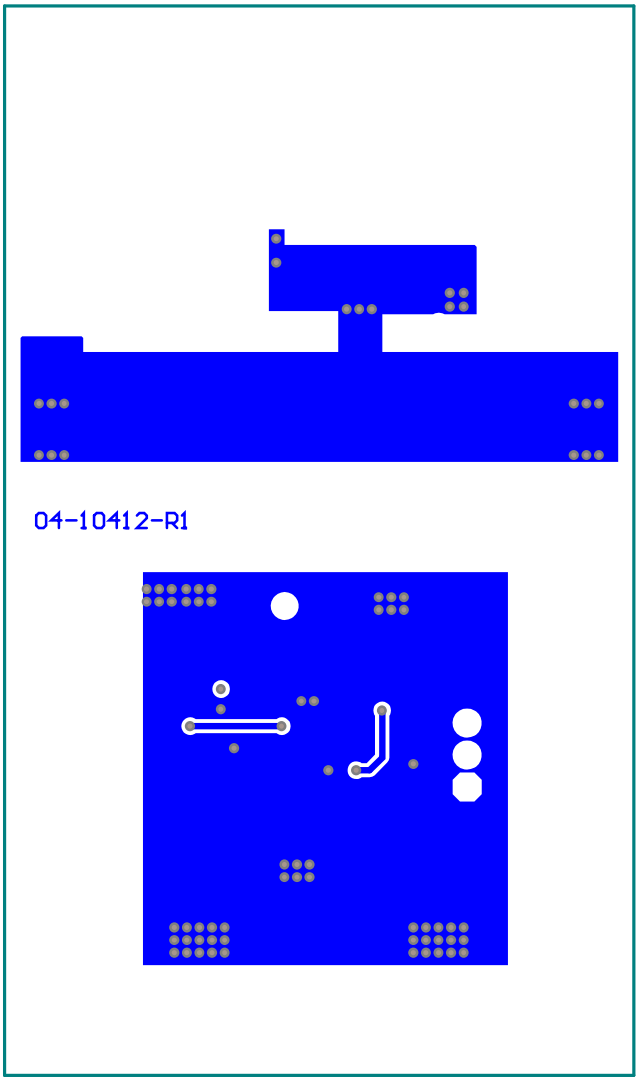


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A.5 BOARD – TOP COPPER



A.6 BOARD – BOTTOM COPPER



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Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Cap. ceramic 1 µF 35V 10% X7R SMD 0805	TDK Corporation	CGA4J3X7R1V105K125AB
1	C2	Cap. ceramic 1 µF 10V 20% X7R SMD 0603	TDK Corporation	C1608X7R1A105M
2	C3, C7	Cap. ceramic 10 µF 16V 20% X5R SMD 0805	TDK Corporation	C2012X5R1C106M/0.85
4	C4, C5, C6, C8	Cap. ceramic 10 µF 50V 20% X7S SMD 1210	TDK Corporation	C3225X7S1H106M
1	C9	Cap. ceramic 0.1 µF 50V 20% X7R SMD 0603	TDK Corporation	C1608X7R1H104M
2	D1, D2	Diode rectifier 1N4148 855 mV 150 mA 75V SOD-323	Diodes® Incorporated	1N4148WS-7
1	D3	Diode Zener 1SMA5918BT3G 5.1V 1.5W DO-214AC_SMA	ON Semiconductor®	1SMA5918BT3G
2	D4, D5	Diode Schottky MBRA140T3G 550 mV 1A 40V DO-214AC_SMA	ON Semiconductor	MBRA140T3G
1	J1	Conn. header-2.54 Male 1x3 tin 5.84 MH th. vert.	Samtec, Inc.	TSW-103-07-T-S
8	J3, J5, J6, J7, J11, J12, J13, J14	Conn. TP loop tin SMD	Harwin Plc	S1751-46R
1	JP1	Mech. hardware jumper 2.54 mm 1x2 handle gold	TE Connectivity	881545-2
1	L1	Inductor 4.7 µH 2A 20% SMD XFL4020	Coilcraft	XFL4020-472MEB
1	L2	Inductor 10 µH 2.2A 20% SMD L4.3W4.3H4.1	Coilcraft	XAL4040-103MEB
4	PAD1, PAD2, PAD3, PAD4	Mech. hardware rubber pad Bumpon Hemisphere 0.630" x 0.312" black	3M	SJ-5027 (BLACK)
2	R1, R2	Resistor 5.6K Ohm 1/4W 1% 1206 SMD	Panasonic® Electronic Components Group	ERJ-8ENF5601V
1	RB	Resistor TKF 9.1k 1% 1/8W SMD 0805	Panasonic Electronic Components Group	ERJ-6ENF9101V
1	RB1	Resistor TKF 174k 1% 1/8W SMD 0805	Panasonic Electronic Components Group	ERJ-6ENF1743V
1	RB2	Resistor TKF 453k 1% 1/8W SMD 0805	Panasonic Electronic Components Group	ERJ-6ENF4533V
1	RT	Resistor TKF 169k 1% 1/8W SMD 0805	Panasonic Electronic Components Group	ERJ-6ENF1693V

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
1	RT1	Resistor TKF 1.1M 1% 1/8W SMD 0805	Panasonic Electronic Components Group	ERJ-6ENF1104V
1	SW3	Switch dip. spst. 24V 25 mA 418121270801 SMD	Wurth Electronik Group	418121270801
9	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9	Conn. TP loop red th.	Keystone Electronics Corp.	5010
1	U1	Microchip analog LDO 5V MCP1804T-5002I/OT SOT-23-5	Microchip Technology Inc.	**MCP1804T-5002I/OT**
2	U2, U3	Microchip analog switcher boost 24V MCP1663T-E/OT SOT-23-5	Microchip Technology Inc.	**MCP1663T-E/OT**

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

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